



Filing Receipt

Filing Date - 2023-09-21 04:41:57 PM

Control Number - 53298

Item Number - 50

September 21, 2023

Public Utility Commission of Texas
Interim Chairman, Kathleen Jackson
Commissioner Will McAdams
Commissioner Lori Cobos
Commissioner Jimmy Glotfelty
1701 N. Congress Avenue
Austin, TX 78711

Re: PUC Project No. 53298, *Wholesale Electric Market Design Implementation*
PUC Project No. 54584, *Reliability Standard for the ERCOT Market*

Dear Interim Chairman and Commissioners:

Please find attached the reliability standard study modeling results table for the full set of 48 scenarios defined for this study iteration.¹ Columns were added to the table to present the total annual capital cost for adding combustion turbine (CT) generation (summing the fixed and variable costs columns), the summer and winter reserve margins for each resource portfolio, and the maximum duration and magnitude; descriptions of these new columns have also been added to the legend accompanying the study results table. An additional table is attached to illustrate how the resource portfolios were developed starting with the portfolio from the December 2022 Capacity, Demand, & Reserves (CDR) Report and performing adaptations in three steps in addition to updating based on the May 2023 CDR.

Based on our findings from this study iteration, ERCOT would recommend that an additional study iteration be performed. ERCOT's proposes the next iteration focus on the following:

- Limit frequency scenario parameters to one day in 10 years, one day in 15 years and one day in 20 years Loss of Load Expectation (LOLE);
- Include a more aggressive coal retirement to reflect 8,300 MWs of both planned gas-steam and coal unit retirements; and
- Add a capacity mix to achieve a frequency target which includes additional Inverter Based Resources.

ERCOT also requests input on narrowing the range of probability of exceedances for further analysis. ERCOT recommends eliminating scenarios with a probability of exceedance

¹ Please note that the modeling updates made to the Strategic Energy & Risk Valuation Model (SERVM) that were described in ERCOT's September 7, 2023 filing apply to the additional 24 scenarios added in this filing.

greater than 3% which would be consistent with policy decisions for development of weatherization standards to the 97th percentile.

In addition, ERCOT is coordinating with Commission Staff to host a workshop in October to review current analysis and obtain stakeholder input. It is anticipated that Commission Staff will issue a memo framing up the ERCOT-hosted workshop and that all information (including stakeholder input) will be included in PUC Project No. 54584.

As recommended by the Independent Market Monitor (IMM), ERCOT is continuing to perform a prompt year study for 2023 and will file results of that study separately once the study is complete.

ERCOT representatives will be available at the September 28, 2023 Open Meeting to present these findings and answer any questions that you may have.

Respectfully submitted,

/s/ Woody Rickerson

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No.	Reliability Standard Framework Inputs			Scenario Parameters				Scenario Outcomes									
	FREQUENCY (LOLE)	DURATION (Hours)	MAGNITUDE (MW)	MW Retired	Capacity Mix to Achieve Frequency Target: 100% CT vs. Max CDR proportional mix of planned Wind, Solar, ESR, Gas	Portfolio Reserve Margin for Summer**	Portfolio Reserve Margin for Winter**	Expected Unserved Energy EUE (MWh)	MW of Additional (new) Dispatchable Generation	Fixed Cost of Additional CT Generation (thousand \$/year)	Total Variable Costs (million \$)	Total Cost (million \$)	Max Duration	Max Magnitude	Exceedance Probability Required for Duration	Exceedance Probability Required for Magnitude	Annual Incremental Fixed Cost of EUE Reduction (\$/year per MWh of avoided EUE)
1	1 in 5*	15	14,000	900	100% CT	10%	14%	7,633	0	0	14,933	14,933	16	26,256	0.06%	3.01%	—
2	1 in 10	15	14,000	900	100% CT	17%	22%	2,597	2,968	353,192	14,756	15,109	15	21,016	0.02%	0.42%	20,133
3	1 in 15	15	14,000	900	100% CT	20%	26%	1,296	5,936	206,384	14,730	15,436	13	16,112	0.00%	0.11%	271,477
4	1 in 20	15	14,000	900	100% CT	22%	28%	853	7,420	882,980	14,720	15,603	13	17,115	0.00%	0.08%	398,637
9	1 in 5*	15	14,000	900	CDR Mix	10%	14%	7,731	0	0	14,929	14,929	16	24,525	0.06%	2.84%	—
10	1 in 10	15	14,000	900	CDR Mix	18%	22%	3,031	2,226	264,894	14,690	14,955	14	20,120	0.00%	0.24%	56,360
11	1 in 15	15	14,000	900	CDR Mix	21%	27%	1,460	5,565	662,235	14,659	15,321	13	17,076	0.00%	0.17%	252,932
12	1 in 20	15	14,000	900	CDR Mix	23%	29%	982	7,049	838,831	14,654	15,493	13	17,930	0.00%	0.10%	369,448
17	1 in 5*	10	10,000	900	100% CT	10%	14%	7,633	0	0	14,933	14,933	16	26,256	4.69%	6.79%	—
18	1 in 10	10	10,000	900	100% CT	17%	22%	2,597	2,968	353,192	14,756	15,109	15	21,016	1.20%	2.32%	20,133
19	1 in 15	10	10,000	900	100% CT	20%	26%	1,296	5,936	206,384	14,730	15,436	13	16,112	0.38%	1.01%	271,477
20	1 in 20	10	10,000	900	100% CT	22%	28%	853	7,420	882,980	14,720	15,603	13	17,115	0.13%	0.51%	398,637
25	1 in 5*	10	10,000	900	CDR Mix	10%	14%	7,731	0	0	14,929	14,929	16	24,525	4.70%	6.80%	—
26	1 in 10	10	10,000	900	CDR Mix	18%	22%	3,031	2,226	264,894	14,690	14,955	14	20,120	1.87%	2.63%	56,360
27	1 in 15	10	10,000	900	CDR Mix	21%	27%	1,460	5,565	662,235	14,659	15,321	13	17,076	0.48%	1.24%	252,932
28	1 in 20	10	10,000	900	CDR Mix	23%	29%	982	7,049	838,831	14,654	15,493	13	17,930	0.19%	0.88%	369,448
33	1 in 5*	5	5,000	900	100% CT	10%	14%	7,633	0	0	14,933	14,933	16	26,256	5.90%	11.52%	—
34	1 in 10	5	5,000	900	100% CT	17%	22%	2,597	2,968	353,192	14,756	15,109	15	21,016	2.95%	6.51%	20,133
35	1 in 15	5	5,000	900	100% CT	20%	26%	1,296	5,936	206,384	14,730	15,436	13	16,112	1.92%	3.85%	271,477
36	1 in 20	5	5,000	900	100% CT	22%	28%	853	7,420	882,980	14,720	15,603	13	17,115	1.26%	2.59%	398,637
41	1 in 5*	5	5,000	900	CDR Mix	10%	14%	7,731	0	0	14,929	14,929	16	24,525	6.19%	12.06%	—
42	1 in 10	5	5,000	900	CDR Mix	18%	22%	3,031	2,226	264,894	14,690	14,955	14	20,120	3.35%	6.61%	56,360
43	1 in 15	5	5,000	900	CDR Mix	21%	27%	1,460	5,565	662,235	14,659	15,321	13	17,076	3.98%	3.81%	252,932
44	1 in 20	5	5,000	900	CDR Mix	23%	29%	982	7,049	838,831	14,654	15,493	13	17,930	1.41%	2.93%	369,448
5	1 in 5*	15	14,000	3,300	100% CT	9%	13%	8,970	0	0	14,949	14,949	17	25,826	0.17%	3.54%	—
6	1 in 10	15	14,000	3,300	100% CT	17%	22%	2,580	5,194	618,086	14,771	15,389	14	18,427	0.00%	0.53%	96,727
7	1 in 15	15	14,000	3,300	100% CT	20%	26%	1,476	8,162	971,278	14,748	15,719	13	15,869	0.00%	0.08%	320,120
8	1 in 20	15	14,000	3,300	100% CT	22%	28%	846	9,646	1,147,874	14,744	15,802	12	16,028	0.00%	0.04%	280,048
13	1 in 5*	15	14,000	3,300	CDR Mix	10%	13%	7,570	0	0	14,831	14,831	15	24,461	0.02%	3.05%	—
14	1 in 10	15	14,000	3,300	CDR Mix	17%	22%	2,987	4,081	485,639	14,700	15,185	14	20,043	0.00%	0.57%	105,963
15	1 in 15	15	14,000	3,300	CDR Mix	21%	27%	1,270	7,791	927,129	14,674	15,601	13	17,040	0.00%	0.13%	257,197
16	1 in 20	15	14,000	3,300	CDR Mix	22%	29%	880	8,904	1,059,576	14,673	15,733	13	17,267	0.00%	0.10%	339,769
21	1 in 5*	10	10,000	3,300	100% CT	9%	13%	8,970	0	0	14,949	14,949	17	25,826	5.62%	7.41%	—
22	1 in 10	10	10,000	3,300	100% CT	17%	22%	2,580	5,194	618,086	14,771	15,389	14	18,427	1.35%	2.13%	96,727
23	1 in 15	10	10,000	3,300	100% CT	20%	26%	1,476	8,162	971,278	14,748	15,719	13	15,869	0.46%	1.39%	320,120
24	1 in 20	10	10,000	3,300	100% CT	22%	28%	846	9,646	1,147,874	14,744	15,802	12	16,028	0.10%	0.90%	280,048
29	1 in 5*	10	10,000	3,300	CDR Mix	10%	13%	7,570	0	0	14,831	14,831	15	24,461	4.90%	6.86%	—
30	1 in 10	10	10,000	3,300	CDR Mix	17%	22%	2,987	4,081	485,639	14,700	15,185	14	20,043	1.66%	2.78%	105,963
31	1 in 15	10	10,000	3,300	CDR Mix	21%	27%	1,270	7,791	927,129	14,674	15,601	13	17,040	0.30%	1.09%	257,197
32	1 in 20	10	10,000	3,300	CDR Mix	22%	29%	880	8,904	1,059,576	14,673	15,733	13	17,267	0.19%	0.78%	339,769
37	1 in 5*	5	5,000	3,300	100% CT	9%	13%	8,970	0	0	14,949	14,949	17	25,826	6.74%	12.67%	—
38	1 in 10	5	5,000	3,300	100% CT	17%	22%	2,580	5,194	618,086	14,771	15,389	14	18,427	3.05%	6.27%	96,727
39	1 in 15	5	5,000	3,300	100% CT	20%	26%	1,476	8,162	971,278	14,748	15,719	13	15,869	1.90%	3.85%	320,120
40	1 in 20	5	5,000	3,300	100% CT	22%	28%	846	9,646	1,147,874	14,744	15,802	12	16,028	1.33%	2.65%	280,048
45	1 in 5*	5	5,000	3,300	CDR Mix	10%	13%	7,570	0	0	14,831	14,831	15	24,461	5.89%	10.82%	—
46	1 in 10	5	5,000	3,300	CDR Mix	17%	22%	2,987	4,081	485,639	14,700	15,185	14	20,043	3.31%	6.67%	105,963
47	1 in 15	5	5,000	3,300	CDR Mix	21%	27%	1,270	7,791	927,129	14,674	15,601	13	17,040	1.81%	3.75%	257,197
48	1 in 20	5	5,000	3,300	CDR Mix	22%	29%	880	8,904	1,059,576	14,673	15,733	13	17,267	1.41%	2.90%	339,769

* The 1 in 5 frequency scenarios required removal of 3,000 MW of coal capacity to achieve this reliability level.

** Reserve margins are calculated with Effective Load Carrying Capabilities for wind, solar, battery storage, and non-PUN thermal resources.

PROPOSED ADDITIONAL 27 SCENARIOS FOR THE NEXT SIMULATION ITERATION

No.	Reliability Standard Framework Inputs			Scenario Parameters		Scenario Outcomes								
	FREQUENCY (LOLE)	DURATION (Hours)	MAGNITUDE (MW)	MW Retired	Capacity Mix to Achieve Frequency Target: 1. May CDR proportional mix of planned Wind, Solar, ESR, Gas 2. May CDR mix with removal of half of the incremental gas and replacement with IBRs (wind, solar and ESR)	Expected Unserved Energy EUE (MWh)	MW's of Additional (new) Dispatchable Generation	Fixed Cost of Additional CT Generation (thousand \$/year)	Total Variable Costs (million \$)	Max Duration	Max Magnitude	Exceedance Probability Required for Duration	Exceedance Probability Required for Magnitude	Annual Incremental Fixed Cost of EUE Reduction (\$/year per MWh of avoided EUE)
1	1 in 10	15	14,000	900	CDR Mix plus IBRs									
2	1 in 15	15	14,000	900	CDR Mix plus IBRs									
3	1 in 20	15	14,000	900	CDR Mix plus IBRs									
4	1 in 10	15	14,000	8,300	CDR Mix plus IBRs									
5	1 in 15	15	14,000	8,300	CDR Mix plus IBRs									
6	1 in 20	15	14,000	8,300	CDR Mix plus IBRs									
7	1 in 10	15	14,000	8,300	CDR Mix									
8	1 in 15	15	14,000	8,300	CDR Mix									
9	1 in 20	15	14,000	8,300	CDR Mix									
10	1 in 10	10	10,000	900	CDR Mix plus IBRs									
11	1 in 15	10	10,000	900	CDR Mix plus IBRs									
12	1 in 20	10	10,000	900	CDR Mix plus IBRs									
13	1 in 10	10	10,000	8,300	CDR Mix plus IBRs									
14	1 in 15	10	10,000	8,300	CDR Mix plus IBRs									
15	1 in 20	10	10,000	8,300	CDR Mix plus IBRs									
16	1 in 10	10	10,000	8,300	CDR Mix									
17	1 in 15	10	10,000	8,300	CDR Mix									
18	1 in 20	10	10,000	8,300	CDR Mix									
19	1 in 10	5	5,000	900	CDR Mix plus IBRs									
20	1 in 15	5	5,000	900	CDR Mix plus IBRs									
21	1 in 20	5	5,000	900	CDR Mix plus IBRs									
22	1 in 10	5	5,000	8,300	CDR Mix plus IBRs									
23	1 in 15	5	5,000	8,300	CDR Mix plus IBRs									
24	1 in 20	5	5,000	8,300	CDR Mix plus IBRs									
25	1 in 10	5	5,000	8,300	CDR Mix									
26	1 in 15	5	5,000	8,300	CDR Mix									
27	1 in 20	5	5,000	8,300	CDR Mix									

* Exact amounts of replacement IBR resources for the "CDR Mix plus IBRs" scenarios requires model runs to determine the quantities that will achieve the target frequency levels.

Results Table Legend

MWs Retired

- This column reports the amount of capacity assumed to have retired in this portfolio, presented in megawatts (MW).

Capacity Mix to Achieve Frequency Target

- This column indicates the capacity mix of the resources added to the portfolio to achieve the targeted frequency: either adding 100% combustion turbines (CTs) or a mix of resources based proportionately on the May 2023 Capacity, Demand & Reserves (CDR) Report.

Portfolio Reserve Margin (Summer and Winter)

- These columns present reserve margins for the summer and winter seasons respectively that reflect the Effective Load Carrying Capability (ELCC) of wind, solar, battery storage and non-Private Use Network (non-PUN) thermal resources.

Expected Unserved Energy

- This column includes the Expected Unserved Energy (EUE) across the 5,250 simulations, effectively a EUE-weighted average for the resource portfolio.

MWs of Additional (new) Dispatchable Generation

- This column reports the amount of “non-summer” CT capacity added to the portfolio to achieve the LOLE in the FREQUENCY column.

Fixed Cost of Additional CT Generation

- This column includes the fixed capital cost of the CT capacity added to the portfolio in thousands of dollars per year.
- The capital cost is based on the Cost of New Entry (CONE) value of \$119/MW-year (i.e., \$119,000/kW-year) and reflects overnight construction costs and levelized fixed Operations & Maintenance (O&M) costs.
- Note that the capital costs reported in the results table only reflect those for the incremental CT additions needed to meet a reliability standard; the capital costs for the solar and battery resources are assumed to be sunk regardless of the reliability standard assumptions.

Total Variable Costs

- This column reflects the sum of total production and capacity scarcity costs in millions of dollars.
- Capacity scarcity costs include load curtailments costs (valued at \$5,000 per MWh of Expected Unserved Energy), the cost of spin/non-spin reserve deployment, dispatched Load Resource costs, and Emergency Response Service costs.
- Note that the Total Variable Costs diminish as the reliability of a portfolio increases. The decreases reflect lower capacity scarcity costs as well as lower production costs due to replacement of retired resources with advanced CTs and, for the CDR Mix scenarios, battery and solar capacity.

Total Cost

- This column presents the sum of annual capital costs for CT capacity by adding the Fixed Cost of Additional CT Generation column and the Total Variable Costs column.

Max Duration

- This column presents the maximum duration (in hours) of the event that occurred in this scenario.

Max Magnitude

- This column presents the maximum magnitude (in MW) of the event that occurred in this scenario.

Exceedance Probability Required for Duration

- This column indicates the likelihood that the duration (in hours) for a portfolio will be higher than the risk tolerance threshold indicated in the DURATION column.
- Note that as the portfolio LOLE decreases, the exceedance probability decreases.
- An exceedance probability of 0% indicates that the portfolio, at the given LOLE, has a maximum event duration that is less than the DURATION threshold.

Exceedance Probability Required for Magnitude

- This column indicates the likelihood that the Loss-of-load event magnitude (in MWs) will be higher than the risk tolerance threshold indicated in the MAGNITUDE column.
- Note that as the portfolio LOLE decreases, the exceedance probability decreases.
- An exceedance probability of 0% indicates that the portfolio, at the given LOLE, has a maximum event magnitude that is less than the MAGNITUDE threshold.

Annual Incremental Fixed Cost of EUE Reduction

- This column reports the annual incremental fixed capital cost needed to avoid a MWh of EUE based on the LOLE of the portfolios.
- For example, moving from a 1-in-5 LOLE CDR mix portfolio (i.e., scenario #9 in the table) to a 1-in-10 LOLE CDR mix portfolio (scenario #10) results in a capital cost of \$56,360 per MWh of avoided EUE. Moving to a 1-in-15 LOLE CDR mix portfolio (scenario #11) increases the cost to \$252,922 per MWh of avoided EUE. The capital cost thus increases by 3.5 times, indicating that the marginal capital cost of additional CT capacity increases significantly as the target LOLE level for a resource portfolio decreases.
- Note that these values do not reflect system costs associated with avoiding scarcity events and the implied cost of unserved energy (i.e., a Value of Lost Load (VOLL) at \$5,000 per MWh).

The table below illustrates the three steps to building the portfolios: (1) initial removal of coal capacity to create the least reliable portfolios (1 in 5 frequency), (2) removal of coal and gas capacity to achieve the scenario retirement levels, and (3) the addition of combustion turbine capacity to achieve the remaining frequency levels.

900 MW Retirement Scenario										
Resource Type	Initial Portfolios		100% CT Scenario				CDR Mix			
	Dec 2022 CDR	Portfolio after Retiring 900 MW of Gas Capacity	Capacity Changes to Achieve 1 in 5 Frequency	Capacity Changes to Achieve 1 in 10 Frequency	Capacity Changes to Achieve 1 in 15 Frequency	Capacity Changes to Achieve 1 in 20 Frequency	Capacity Changes to Achieve 1 in 5 Frequency	Capacity Changes to Achieve 1 in 10 Frequency	Capacity Changes to Achieve 1 in 15 Frequency	Capacity Changes to Achieve 1 in 20 Frequency
Coal	13,630	13,630	(3,000)				(3,000)			
Gas	55,415	54,515								
Wind	41,853	41,853								
Solar	44,775	44,775						782	782	782
Battery Storage	10,945	10,945						3,082	3,082	3,082
New CTs	-	-		2,968	5,936	7,420		2,226	5,565	7,049
TOTAL	166,618	165,718	162,718	168,686	171,654	173,138	162,718	171,808	175,147	176,631

3,300 MW Retirement Scenario										
Resource Type	Initial Portfolios		100% CT Scenario				CDR Mix			
	Dec 2022 CDR	Portfolio after Retiring 3,300 MW (900 Gas/2,400 Coal)	Capacity Changes to Achieve 1 in 5 Frequency	Capacity Changes to Achieve 1 in 10 Frequency	Capacity Changes to Achieve 1 in 15 Frequency	Capacity Changes to Achieve 1 in 20 Frequency	Capacity Change to Achieve 1 in 5 Frequency*	Capacity Changes to Achieve 1 in 10 Frequency	Capacity Changes to Achieve 1 in 15 Frequency	Capacity Changes to Achieve 1 in 20 Frequency
Coal	13,630	11,230	(1,500)	-	-	-	(965)	-	-	-
Gas	55,415	54,515	-	-	-	-	-	-	-	-
Wind	41,853	41,853	-	-	-	-	-	-	-	-
Solar	44,775	44,775	-	-	-	-	782	782	782	782
Battery Storage	10,945	10,945	-	-	-	-	3,082	3,082	3,082	3,082
New CTs	-	-	-	5,194	8,162	9,646	-	4,081	7,791	8,904
TOTAL	166,618	163,318	164,218	170,912	173,880	175,364	168,617	173,663	177,373	178,486

* For the CDR Mix scenario, the addition of IBR resources reduces the amount of coal capacity needed to achieve the 1 in 5 frequency target relative to the amount needed for the 100% CT scenario.